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ASSESSING STUDENT TEACHERS' UNDERSTANDING OF THE BIOLOGY SYLLABUS THROUGH CONCEPT MAPPING

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Abstract. A concept map is a visual illustration displaying the organization of concepts/ideas and outlining the relationship among or between those concepts. The application of concept map in the teaching and learning process varies depending on the purpose of its usage. Educators/teachers have used concept mapping to present a topic, relate a new topic to the previous topic, investigate/gather students' prior knowledge or even evaluate students' understanding of the lesson or topic. This paper describes the outcome of an exercise carried out with one hundred undergraduates student teachers (preservice teachers) enrolled in a Biology Teaching Methods course, a third year course in a four-year Teacher Education Programme. The students, working in groups of 3 to 4, were assigned to construct a concept map showing their understanding of a part of the form four (grade ten) biology syllabus/curriculum offered in the Malaysian Secondary School System. The concept maps were derived from materials taken from the syllabus, and consisted of scientific concepts as well as the scientific skills and values associated with the chapters and their relationships. The purpose of this assignment was to familiarize the students with the syllabus and to make them understand the scope of the syllabus itself so that these preservice teachers will know what to focus on when they actually teach in the classroom. Through this exercise, not only the students' understanding of the syllabus was revealed but misconceptions among the students on the syllabus and the concept of scientific skills and values were also detected.

1 Introduction.

A concept map is a visual illustration displaying the organization of concepts/ideas and outlining the relationship among or between those concepts (Geller, 2004; Cañas, Coffey, Carnot, Feltovich, Hoffman & Novak, 2003). According to Novak & Gowin (1984), concept maps are representations of organized knowledge in diagrams. The organization of the knowledge can be hierarchical and/or linear (West, Farmer & Wolf, 1991). Jones, Palincsar, Ogle & Carr (1987) categorized three different and common types of concept maps: the spider map, the chain map and the hierarchy maps. There are other types of concept maps such as the hybrids of those three common maps like the hierarchy map that has a spider map as part of it (West, Farmer & Wolf, 1991). The concepts/ ideas in the concept map are linked to one another by lines or arrows or a combination of lines and arrows. Lines denotes the relationship from the upper concepts to the lower concepts whereas arrows denotes the direction of the relationship of the concepts pointed by the arrow (Safayeni, Derbentseva & Cañas, 2003). The chain map is best used in narrating chain of events or describing the steps in a procedure; the spider maps are used to illustrate the many branches of ideas connected to that concept and the hierarchy maps are used in describing the different levels of concepts connected to that main concept.

Studies on the use of concept mapping reveal that it is not only used in educational institutions, but also in business and government The use of concept map extend to a wide span of age group ranging from elementary/primary school children to scientists from NASA (Leake, Maguitman, Reichherzer, Cañas, Carvalho, Arguuedas, Brenes & Eskridge, 2003). A technical report submitted to the Chief of Naval Education and Training in Florida by Cañas, Carnot, Coffey, Feltovich and Novak (2003) described the use of concept mapping in business and government as a tool in capturing knowledge, support of group processes like brainstorming and also serve as a tool in achieving consensus. This is due to the nature of the concept map itself that contain the ideas/concept to be discussed in orderly manner fashioned /arranged by the people involved. Concept map helps the presenter to convey his/her idea /message across to others making communication simpler because concept map provides the 'overall view' or some call it 'the big picture' of the knowledge/ideas concerned.

The use of concept map in teaching and learning is not limited to the traditional classroom but has been expanded to the electronic media and to distance learning (Coffey & Cañas, 2000). The Institute for Human and Machine Cognition (IHMC) had developed CmapTools, an electronic concept mapping tool available publicly for constructing concept maps, acquiring and sharing of knowledge (http://cmap.ihmc.us). Concept map can be used in curriculum planning (Edmonson, 1995, Ferry et al., 1998, Horton et al., 1993 and Novak, 2003) for showing the topics/contents of a course/ programme or used by educator at the beginning of a lesson in introducing a topic to the students. Other uses of concept mapping include tools for learning (Ault,1985, Chmeilewski & Dansereau,1998, McCagg, 1991) and evaluation or assessment (Aidman & Eggan, 1998, Rice , Ryan & Samson, 1998 and Soyibo, 1995).

Concept mapping is an effective tool as visual representation of schema in teacher preparation course (Mason, 1990). Concept mapping can also be used as a tool in capturing students' previous knowledge before starting with a new topic. Once students' previous knowledge is captured, teacher can assess students' misconception (West, & Pines, 1985) and decide on the appropriate constructivist teaching approach to use. As purported in constructivism, students are not 'a blank slate', they make connection or relate their previous knowledge to the new knowledge learnt. Representing knowledge in the visual format of a concept map allows one to gain an overview of the domain of knowledge. Jonasses (1996) argues that students show some of their best thinking when they try to represent something graphically, and thinking is a necessary condition for learning. Concept maps can also be used as assessment tools. The framework of a concept map assessment consists of three items: the task, the format of student's response and the scoring system (Ruiz-Primo & Shavelson, 1996). The task is the demand requiring srudents to provide evidence of their knowledge in a content area. The format for student's response can be paper-and-pencil response (Wallace & Mintzes,1990; Markham, Mintzes & Jones, 1994) where students drew the concept map on a blank page; oral response (Nakhleh & Krajcik, 1991) or computer response (Fisher, 1990) or even filling in the prestructured skeleton map (Anderson & Huang, 1989). Maps will definitely vary from individual to individual. Hence, it is useful to be able to evaluate or assess different maps. Cronin, Dekkers and Dunn (1982) for instance developed an evaluation scheme based on Ausubelian learning principles. Wallace & Mintzes (1990) devised a scoring system whereby scoring is made based on the components involved.

2 Purpose

This paper describes the outcome of an exercise carried out with one hundred undergraduates student teachers (preservice teachers) enrolled in a Biology Teaching Methods course, a third year course in a four-year Teacher Education Programme. Concept mapping is used as an evaluation tool for assessing the students' understanding of biology syllabus for Malaysian schools . The syllabus concerned is the form four/ grade ten biology syllabus. The purpose of this exercise was to familiarize the students with the syllabus and to make them understand the scope of the syllabus itself so that these preservice teachers will know what to focus on when they actually teach in the classroom. Once the teacher understands the scope of the syllabus well, he/she will be able to adjust or manipulate his/her teaching according to the different situations facing him/her. The teacher will be able to give the best examples of the concept involved using the examples most familiar to the students.

Percentage	Items	Sub items
5%	Inclusion of the topics	Four themes: 1.Introduction to Biology (1 chapter) 2.Investigating cell as a basic unit of life (5 chapters) 3.Investigating physiology (2 chapters) 4.Investigating the interrelationship of life and it's environment. (2 chapters)
5%	Proposition on the link	Correct proposition between the concepts
30%	Levels of hierarchy	Each of the chapters in the themes arranged according to the different level of hierarchy in terms of the cellular approach in biology content (the simple/less complex topics to a more complex topics)
30%	Science process skills	observation, classification, measure and using numbers, making inference, predicting, using of time and spatial skill, interpreting data, control the variables, making hypothesis, experimenting and communicating
30%	Values	Appreciate balance in nature, rational, objective, cooperative, responsible, critical & analytic, showing interests in science, honest, hard working

Table 1: Content of the concept map and weightage.

3 Methodology

The sample consisted of one hundred student teachers (100) enrolled in a Biology Teaching Methods course in first semester of 2003/2004 session (June -September 2003). The course is a third year course in a four-year Teacher Education Programme at a university level in Malaysia. Prior to the task, these students were given four hours of lectures on the components of the Malaysian secondary school Biology syllabus for form four (grade ten). They were also given three hours of lecture on concept mapping and futher guidance by the lecturer involved during their construction of the concept map. Students work in groups of three or four : There were 28 groups of students involved in this exercise (16 groups of four students and 12 groups of three students). They were required to construct a concept map from scratch on the Malaysian Secondary School Biology syllabus for form four. The format for student's response is paper-and-pencil response as used by Markham, Mintzes & Jones (1994) and Wallace & Mintzes (1990). Students were encouraged to include other graphics such as symbols or pictures in their concept map. The scoring system used was an adaptation based on scoring system used by Wallace & Mintzes (1990) whereby scoring is made based on the components involved. The topics required to be included in the map are the themes, the scientific skills and the values suitable for each theme involved. The materials were from the lecture notes and also the Malaysian Secondary School Biology Syllabus For Form Four (Kementerian Pendidikan Malaysia, 2001). Time given to complete the task was eight weeks. Scoring is made based on the criteria set for each of the components. 30% is alloted to the levels of hierarchy of the chapters in the theme of the concept map, 5% for the complete inclusion of the topics, 5% for the correct proposition, 30% for the correct/appropriate science process skills in each theme and 30% for the correct/appropriate scientific and noble values associated with the topic. The content of the concept map is summarized in Table 1.

Group	**Inclusion of the topics** 5%	**Levels of hierarchy** 30%	**Science process skills** 30%	**Values** 30%	**Preposition** 5%	**Total**
1	5	20	28	29	5	87
2	5	25	29	28	4	91
3	5	20	15*	28	3	71
4	5	15	10*	28	2	60
5	5	27	30	28	4	94
6	5	17	20	25	1	68
7	5	28	26	26	4	89
8	5	28	15*	25	3	76
9	4	10	20*	20	1	55
10	5	20	20*	25	1	71
11	5	20	15	28	1	74
12	5	29	15*	15	4	68
13	5	20	29	27	2	83
14	5	20	30	30	3	88
15	5	15	20	25	3	68
16	5	26	05	10	4	50
17	5	15	25	15	1	61
18	5	25	27	28	5	90
19	5	25	25	25	1	81
20	5	20	15	15	4	59
21	5	28	16*	20	5	74
22	5	25	16	16	2	64
23	5	15	10	10	4	44
24	5	18	26	25	2	76
25	5	28	15	15	5	68
26	5	25	15	15	5	65
27	5	20	15	05	3	48
28	5	15	28	15	5	68

Note : * denotes misconception

Table 2: The score of each group in each components in the concept map

4 Results and discussion

The results from the analysis of the exercise is summarized in table 2. The results showed that the lowest total score is 44 and the highest total score is 94. The mean (average) total score is 71.11 indicating that on the overall, group performance is good as the score is above 50%. Even the lowest score is above 30% .

The focus on this exercise was on the understanding of the content of the syllabus. Table 3 states the average and the achievement in each compenents on this concept map.

Aspects	Inclusion of the topics	Hierarchy	Science process skills	Values	Preposition
Mean score	4.96	21.39	20.00	19.03	3.28
Achievement percentage	99.2	71.30	66.66	63.43	65.60

Table 3: Mean Score and Achievement Percentage in each components of the concept map.

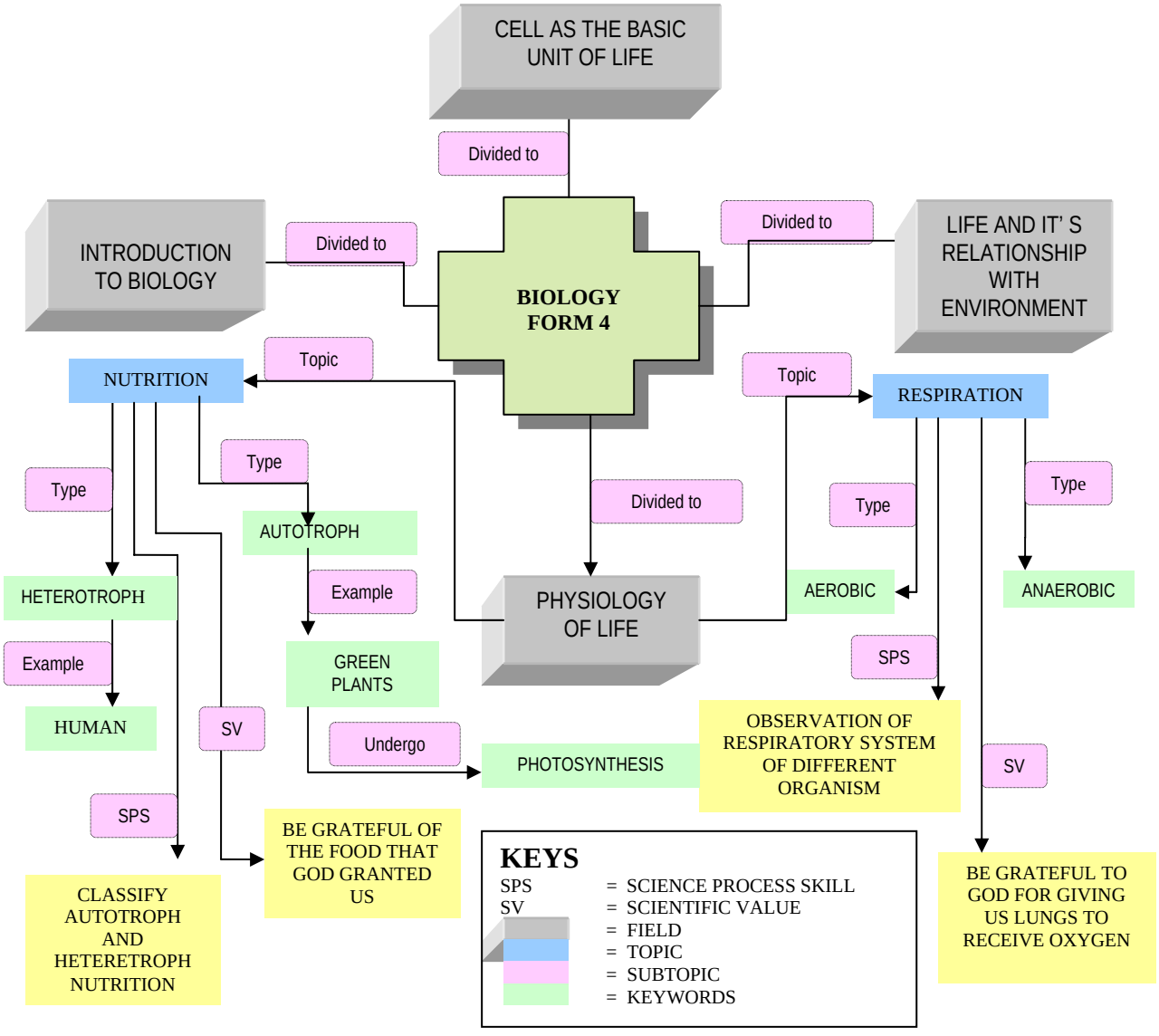

Figure 1. Caption of the concept map of Biology Syllabus for Form Four.

Misconceptions were detected in the area of science process skills. Seven groups showed some misconceptions on science process skills. Thinking skills was stated the same as science process skills. Examples of this misconception is classifying (science process skill) which was stated to be the same as compare and contrast (which is a thinking skill), interpreting data became interpreting concepts, defining operationally was confused as memorizing a set of definitions and observing (a science process skill) is confused as visualizing. Groups that showed misconceptions in the science process skills also did not state the specific science process skills associated with the topics/concepts but only stated the science process skill in general. For example, in the topic of mitosis, the specific science process skill is observing the cells under microscope but the science process skill that was stated was only observation.

The results (Table 3) shows that students knew all the topics involved in the syllabus as the achievement percentage (mean score ÷ weightage) for the inclusion of topics is 99.2%. Students' understanding of the arrangement order of the topics involved in all the chapters is less than the first component (the inclusion of topics) but still high (71.30%). This is followed by their knowledge on science skills (66.66%), the preposition used that showed students' understanding of the relationship of the concepts (65.60%) and the values appropriate for the topics/concepts involved (63.43%). It was noted that groups that scored less in this component (values) not only list just a few values but also stated the value generally without giving specific example. For example, in the topic of Balanced Ecosystem, one of the values that could be imparted through the teaching of the topic is that students should appreciate the balance in nature; not just appreciate God's gift to humankind.

5 Conclusions

This exercise showed how concept mapping can be used to assess the student teachers' understanding of Biology Syllabus. In constructing the concept map, students had to evaluate their own understanding and synthesize the knowledge when they arrange the hierarchy of the topics involved, assigned the preposition on the links and synthesize the specific examples of science skills and values associated with the specific concept/topic. These activities require a high level cognitive performance as identified by Bloom. Through this exercise, students were more familiar with the scope of the biology syllabus and aware of the related scintific skills and values that needed to be integrated in the teaching of Biology in the classrooms. It is hoped that once these student teachers have undergone this concept mapping exercise, they will appreciate and apply concept mapping with their students so that biology is presented in a connected manner and biology learning becomes more meaningful.

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